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LCAD – High Performance Computing Lab

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**Group on Computational Micro– and  
Bio–fluid Dynamics**

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# Interests and lines of research

- **Microfluidics:**

- Surface forces are dominant at the microscale: **Develop simulation methods for flows strongly dominated by surface tension effects.** Strongly nonlinear geometry-induced effects. Absence of inertia (the equations lack the time-derivative term!).
- At small scales fluids are less homogeneous: **Develop methods for fluids with suspended particles, floating drops of other fluid, or even small biological species** (bacteria...). Things move, interfaces move, meshes move (ALE, front-tracking), sometimes not (Eulerian).
- Some things behave weirdly at small scale: **Develop methods for models specific for the microscale.** Dissipation at triple-phase lines. Electroosmotic and electrophoretic effects. Brownian forces.

- **Biofluidics:**

- Biological membranes, such as cell membranes, are really complex mechanical objects: **Develop methods to simulate the behavior of lipid bilayers, incorporating the elastic-like behavior of the cytoskeleton and the fluidic behavior of the bilayer of lipid molecules.** Solve equations of solids and liquids in curved two-dimensional domain defined by the cell surface, coupled with both the interior and exterior fluids.
- Hemodynamic networks are as complex mechanical objects as biological membranes!: **Develop methods that allow the simulation of the complete human circulatory system.** Combine methods of different dimensionality, couple the arterial tree with the venous one, with the capillary bed, with the pulmonary circulation, and adjust to fit a realistic human metabolism.

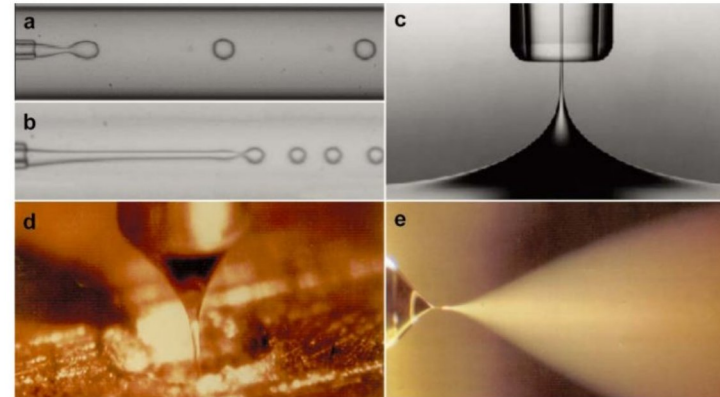
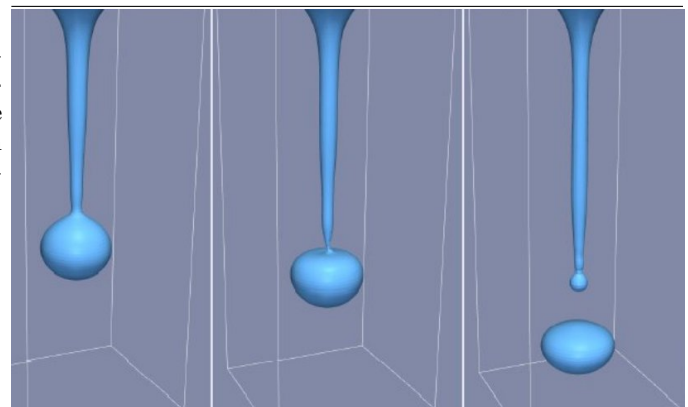


Figure 1

(a) Dripping mode, (b) jetting mode, (c) selective withdrawal, (d) flow focusing, (e) electro spray.

From Barrero & Loscertales, 2007

## Improved ALE and Level set finite element methods



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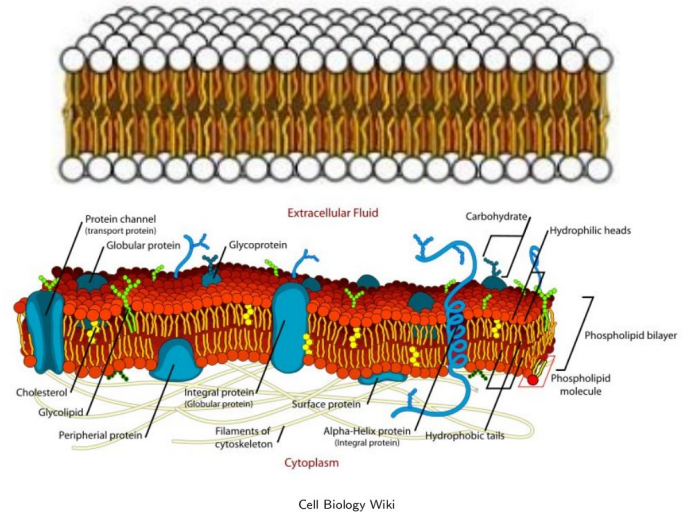
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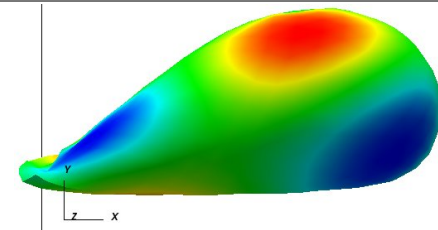
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Bilayer sheet



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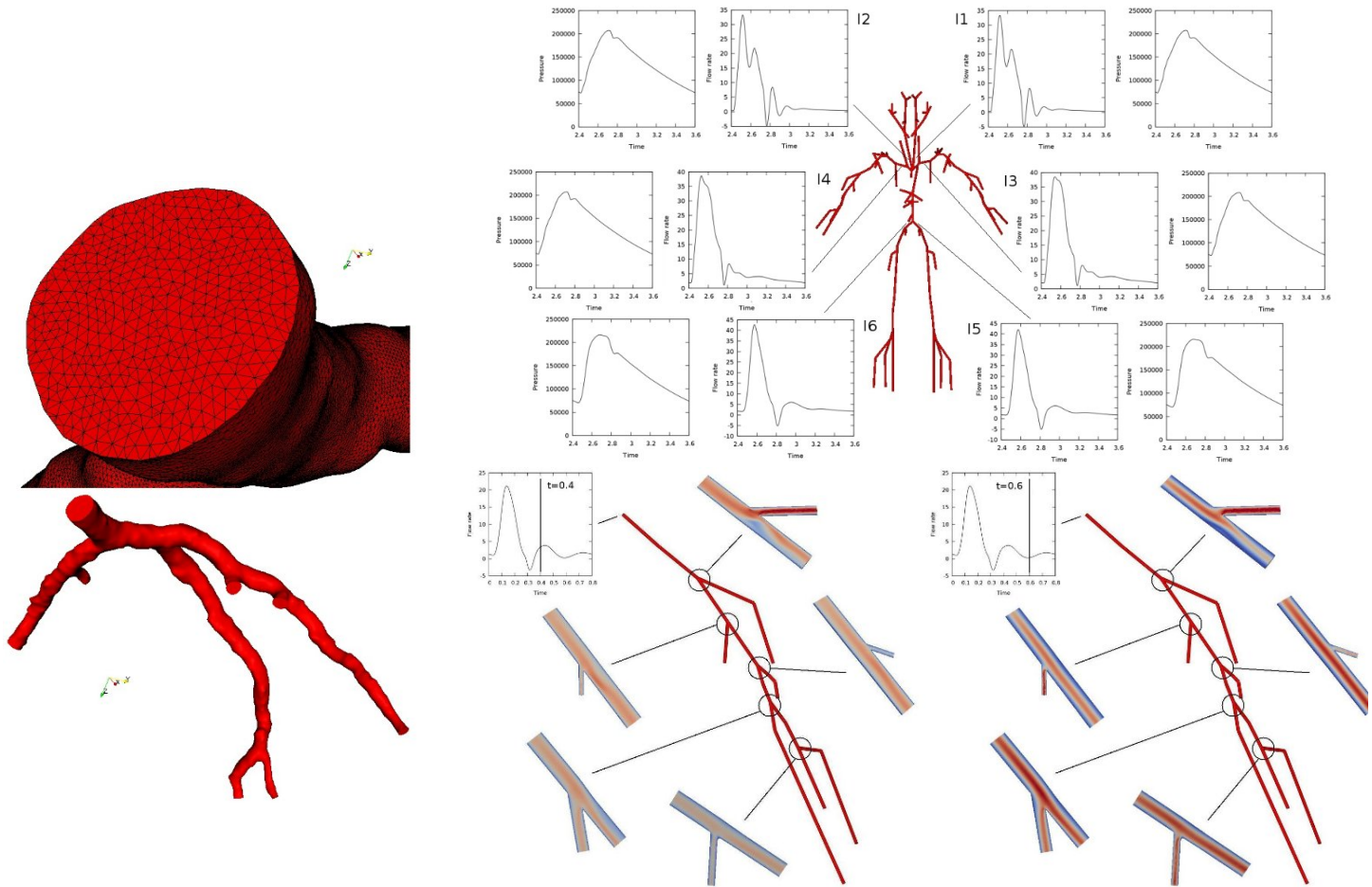


Figure 21: Velocity magnitude at different time instants through the cardiac cycle.